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1. Your reference MPS/7002

2. Patent 9824927.9
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3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Aldridge Piling Equipment (Hire) Company Limited
Conduit Road, Conduit Industrial Estate,
Norton Canes, Cannock, Staffordshire, WS11 3TJ.

Patents ADP number *(if you know it)* 30252100 1

If the applicant is a corporate body, give the country/state of its incorporation United Kingdom

4. Title of the invention

Actuator Apparatus

5. Name of your agent *(if you have one)*

Swindell & Pearson

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

48 Friar Gate,
Derby DE1 1GY

Patents ADP number *(if you know it)* 00001578001

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Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

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12. Name and daytime telephone number of person to contact in the United Kingdom: Mr. M.P. Skinner - 01332 367051

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Actuator Apparatus

The present invention relates to actuator apparatus and in particular, but not exclusively, to hydraulic apparatus for installing or extracting pile elements and like members by vibration or impact.

The apparatus may be used with pile elements as defined in British Standard specification BS EN 996; 1996 entitled "Piling Equipment - Safety Standards". Piles and like members are driven into the ground for a variety of reasons in the construction industry and other industries. In addition to pile elements as defined in BS EN 996, other types of element are conventionally installed in a similar manner, such as steel trench sheeting, and PVC, polystyrene and glass fibre composite piles. These may be used for shoring up a trench wall, protection against erosion, etc. Devices may also be driven in a similar manner for soil compaction.

For simplicity, the single term "pile element" is used in a broader manner in this specification than in BS EN 996, in order to encompass all of these alternatives and similar items drivable into the ground. In addition, apparatus may be used to withdraw members from the ground by applying forces in the opposite direction. Again for simplicity, the term "installation" is used herein to refer to the application of forces for causing items to penetrate the ground, "extraction" is used to refer to the application of forces for causing items to be withdrawn from the ground, and "driving" is used to refer to installation and extraction.

Various devices have been proposed for providing driving forces, by vibration, impact or the application of static forces. The nature and magnitude of forces to be used will in practice be chosen according to a number of factors, including the soil type and the nature of the pile element being driven. For instance, in loose, non-cohesive soils, vibration is often the quickest and quietest technique. Relatively high frequency vibration is generally attenuated more quickly and is therefore preferable for use near populated areas,

particularly brown field sites. Other soil types are better served by impact driving, but this can cause problems from noise and shock waves. Legislation, particularly concerning health and safety, is becoming increasingly strict in respect of vibration and noise created by piling operations, and this presents a further factor influencing the choice of technique.

It is therefore conventional to build apparatus in a variety of different sizes and operating in a variety of different ways, so that an appropriate apparatus can be chosen for a particular situation. Unfortunately, problems with delay can then occur if it is found that the choice was inappropriate. Alternatively, equipment may be provided unnecessarily, so that alternatives are available on-site if required, but remain unused if not.

The present invention seeks to obviate or mitigate these or other disadvantages of the prior art.

The invention provides actuator apparatus for driving piles and like members, comprising piston means operable to create driving forces from a supply of pressurised fluid, and valve means operable to supply pressurised fluid to the piston means according to a predetermined sequence, to cause the apparatus to execute a first operation, the valve means and the piston means being housed within a common block member, and the valve means or the piston means or both being removable from the block member for replacement by an alternative means operable within the block member to cause the apparatus to execute an alternative operation.

Preferably the valve means is removable for replacement with an alternative valve means operable to supply fluid according to an alternative sequence. The valve means may comprise a spindle movable within a housing, there being hydraulic ports in the housing walls, and the spindle carrying partitions which serve to change the connections between the hydraulic ports in accordance with the spindle position. The spindle is preferably rotatable to provide port connections in accordance with the predetermined sequence. The

spindle may be axially movable to change the predetermined sequence. The spindle may have a first axial position at which a wider fluid path is provided to one face of the piston means than to the other, and be movable to a second axial position at which a narrower fluid path is provided to the said one face than to the other. The valve means may have a port having a width which is not constant in the axial direction of the spindle, whereby the effective width of the fluid path to the piston means can be set by setting the axial position of the spindle. The spindle may provide drive alternatively to opposite faces of a piston of the piston means, whereby to create reciprocation.

The spindle may be formed to complete a plurality of cycles of the piston means for each full turn of the spindle. The spindle may have a first axial position in which a first number of cycles are completed for each full turn of the spindle and a second axial position in which a different number of cycles is completed for each full term. The fluid path to the piston means may be relatively narrow in the first axial position, and relatively wide in the second axial position.

The valve means may comprise at least one member which is movable to alternative positions to cause the predetermined sequence to change in accordance with its position. Preferably, the said member is movable as aforesaid while the apparatus is operating.

The apparatus may further comprise intermediate means to which driving forces are provided by the piston means, and which convey driving forces to clamping members by which a workpiece may be clamped. The clamping members preferably extend at an angle to the intermediate means to allow side or end clamping of a workpiece. The intermediate means is preferably elongate, and preferably extends to one side of the common block member. The clamping members may extend substantially perpendicular to the intermediate means.

The intermediate means may extend through a passage within the piston

means, and have enlarged heads against which the piston means may act in either of two opposite directions.

The common block member may be arranged for attachment to the block member of a like apparatus, to allow the piston means of one apparatus to apply impact forces to the piston means of the other apparatus, the other apparatus being operable to provide vibratory forces. The apparatus is preferably adapted for resilient attachment to a mounting bracket by means of which the apparatus may be supported by a conventional support arrangement. The support arrangement may be provided on a support machine, preferably operable to apply crowd forces to the apparatus and preferably able to supply pressurised fluid to the apparatus.

Embodiments of the present invention will now be described in more detail, by way of example only, and with reference to the accompanying drawings, in which:-

Fig. 1 is a simplified side elevation of an actuator according to the present invention;

Fig. 2 is a plan view of the actuator of Fig. 1;

Fig. 3 is a vertical section through the actuator of Fig. 1;

Fig. 4 is a more detailed cut-away view, on an enlarged scale;

Figs. 5 to 8 are sections through alternative valve arrangements;

Fig. 9 is a view corresponding with Fig. 4 and showing an alternative piston arrangement; and

Fig. 10 is a vertical section through a combined vibration/impact

arrangement according to the invention.

Turning first to Figs. 1 to 3, there is shown a piling machine 10 for use in installing or extracting piles and the like. The machine 10 has a common block 12 supported at 14, as will be described, and having jaws 16 for gripping a pile. Within the block 12, the machine 10 has a double-acting piston 18 alongside which there is a space 20 for a control valve arrangement (omitted from Fig. 3 for clarity) which provides hydraulic fluid to the piston 18, during use.

The block 12 is supported at 13 by resilient mountings on a mounting bracket 15, which is in turn mounted at 14 on the second bracket 22 of an excavator or like hydraulic machine. The second bracket 22 carries a vertical hinge pin 24 by fingers 26. A second set of fingers 28 attach the bracket 15 to the pin 24, which is rotatable relative to the fingers 26, allowing the machine 10 to be turned relative to the second bracket 22, about a generally vertical axis. This makes use of the apparatus 10 more versatile, by allowing access to a workpiece from a variety of angles and in confined spaces.

The second bracket 22 is preferably mounted on the arms of an excavator or like machine, preferably one which can apply a downward force ("crowd") to the machine 10 while in use, to assist in driving a pile. The presence of resilient mountings at 13 helps isolate the excavator from impact and vibration created within the machine 10.

The bottom end of the piston 18 carries a plate 30 from which the jaws 16 project. One jaw, 16A is fixed in position. The other jaw is mounted at a pivot 32 part way along its length. A clamp piston 34 is provided, acting between the free end of the jaw 16B, and the fixed jaw 16A or a fixed point on the plate 30. Consequently, pressurising the piston 34 to extend the piston arm will cause the jaw 16B to pivot at 32 and move toward the jaw 16A, to clamp a workpiece 36, generally at 38, between gripping plates 39 carried by the jaws 16. It can be seen from the drawings that the jaws 16 reach out sideways (i.e. generally horizontally and transverse to the driving direction) to reach the pile

36. The plates 39 reach down from the ends of the jaws 16, extending below any other part of the machine 10. This increases versatility of the device in allowing a pile member to be gripped from the side or from above. When gripped from the side, the whole of the plate 39 can be used, which is particularly preferred for relatively fragile pile members such as light metal trench sheeting, wooden or concrete sections, glass fibre or PVC pile members. Side driving allows driving even if the top of the pile is beyond the reach of the excavator arms on which the apparatus is mounted. However, end driving can be achieved by locating the machine 10 above the pile member, which is gripped between the lower extremities of the plates 39.

The piston 18 shown in Fig. 3 is of generally cylindrical form, movable in a generally vertical direction in bores 40 and a central chamber 42. The piston 18 carries a shoulder 44 within the chamber 42. The diameter of the piston 18 is smaller above the shoulder 44 than below, so that the surface area of the shoulder 44 transverse to the piston axis is greater on the upper surface of the shoulder 44 than on the lower surface.

Upper and lower hydraulic ports 46, 48 communicate between the chamber 42 and the valve space 20, allowing valve arrangements (to be described) to provide hydraulic fluid to the upper or lower face of the shoulder 44, in order to drive a piston up or down.

In Figs. 1 to 3, the piston 18 is permanently affixed to the plate 30 by means of attachment pins 50, so that reciprocating vertical movement of the piston 18 causes vibration of the plate 30, and thus allows a pile 36 to be driven by vibration.

The arrangement shown in Fig. 4 is very similar to the arrangement of Fig. 3, but shows an alternative piston 18B which is no longer permanently attached to the plate 30. Rather, the lower face 52 can move up, clear of the upper face 54 of an anvil 55 attached to the plate 30, in place of the piston, by means of the pins 50. The face 52 can also move down to strike the face 54, so

that impact (or "percussive") forces are generated in this arrangement. The anvil 55 is supported from below by a compression spring arrangement 57, which serves to push the anvil 55 up into the block 12 after each strike. The spring arrangement 57 also serves to isolate the main body of the machine from shock forces.

Fig. 4 illustrates a valve arrangement 56 located in the space 20. The arrangement 56 is a rotary valve arrangement driven by a motor 58 (which may be a hydraulic motor) through a shaft 60 to which various components (including the motor) are splined. Bearings 62 are provided to support components of the arrangement 56 during rotation. Splines connect the various rotating components and also allow axial movement, for reasons to be explained below.

The valve arrangement 56 is in the form of a removable cartridge, and has an inlet 64 for pressurised hydraulic fluid, and a exhaust outlet 66. The inlet 64 communicates with an inner space 68 around the shaft 60 and bounded at its outer extremity by partitions 70. However, two outlets 72 are provided from the inner space 68. The upper outlet 72A is in communication with the upper port 46 when the arrangement 56 is in the rotary position as shown in Fig. 4. The lower outlet 72B is closed by the walls of the valve arrangement. Thus, in this position, hydraulic pressure is being supplied to the upper face of the shoulder 44, driving the piston 18 downwardly. However, it can readily be seen from Fig. 4 that after the valve arrangement 56 has turned through 180° about the shaft 60, the upper outlet 72A will have moved clear of the upper port 46, and the lower outlet 72B will have come into communication with the lower port 48. In this position, hydraulic pressure passes to the lower face of the shoulder 44, driving the piston 18 upwardly, for the return stroke. It can be appreciated that with the surface area of the upper face of the shoulder 44 being greater than the surface area of the lower face, the piston 18 is driven downwardly with greater force than it is returned upwardly.

The valve arrangement 56 also provides a return path for hydraulic fluid

to exhaust at 66. An outer space 74 extends around the partition 70 and communicates at 76 with the exhaust bore 66. The exhaust port 76 will not communicate with the pressure source 64 or outlets 72 at any angular position of the valve arrangement. Thus, in the position shown in Fig. 4, the lower port 48 is connected through the outer space 74 to the exhaust 66. After the arrangement 56 turns through 180°, the upper port 46 will be in communication with the outer space 74, allowing hydraulic fluid to pass around the partition 70, to reach the exhaust 66. Thus, by applying hydraulic pressure to the inlet 64 and allowing exhausting through the exhaust 66, while turning the valve arrangement 56, the piston 18 is reciprocated by alternately applying pressure above and below the shoulder 44, while exhausting the other face of the shoulder 44.

The valve arrangement shown in Fig. 4 represents a relatively simple operating sequence, appropriate for simple impact installation of a pile member clamped in the jaws 16, but not for extraction. However, an extraction arrangement can be formed by replacing the piston with one having a larger lower face and smaller upper face, and by attaching the piston to the plate 30 in place of the anvil 55, in the manner of Figs. 1 to 3. In other circumstances, alternative operating sequences may be required. In particular, the operating sequence may require to be different if impact is used rather than vibration, or according to the nature of the pile element being driven or the ground into which it is being installed or from which it is being extracted. For all of these reasons, and in accordance with the invention, the valve arrangement 56 is replaceable in the piling machine 10, by removal of a closure plate 80, so that the valve arrangement 56 can be withdrawn as a single unit, sliding up the splined motor shaft 60. A replacement cartridge containing an alternative valve arrangement 56 can then be placed into the space 20, to change the operating sequence of the machine 10, as will now be described with particular reference to Figs. 5 to 8, which show alternative valve arrangements in isolation.

In each of Figs. 5 to 8, there is shown a vertical section through the valve arrangement, corresponding to the view in Fig. 4, together with inset views of

sections at various positions. In each case, the horizontal section is labelled with a suffix corresponding to the section line in the main drawing so that, for instance, Fig. 5B is a horizontal section at the line B-B in Fig. 5. In addition, it must be understood that the section views are sections "at" the corresponding height, not "from" the corresponding height, so that only those components present at the section plane are shown in the section drawing.

The arrangement 56A in Fig. 5 differs from that in Fig. 4 principally in that two cycles of the piston 18 are produced for each complete revolution of the valve 56A. This is achieved by providing two upper outlets 82A from the inner space 68A, at 180° from each other. Partitions 84A separate the upper outlets 82A from upper extensions 86 of the outer space 74A. Similar partitions 84B are provided at the height of the lower outlet 72B, so that in the condition shown, the outer space 74A communicates with the port 72B to connect this with the vent 66, while the upper outlet 82A is coupled through the inner space 68A to the inlet 64. This provides the down stroke of the piston 18.

As the valve arrangement turns through 90°, including the partitions 84A, 84B, the inner space 68A and positive hydraulic pressure comes in communication with the lower port 82B between the partitions 84B, whereas the outer space 86 around the partitions 84A comes into communication with the upper port 72A, so that the return stroke commences, with hydraulic pressure being supplied under the piston 18. After a second 90° turn of the valve arrangement, the arrangement reverses again, creating a second down stroke. Consequently, this valve arrangement creates an operating frequency which is twice the frequency of the arrangement of Fig. 4 (at a given motor speed).

Fig. 6 shows a more complex arrangement in which the partition elements within the valve arrangement are axially movable, with the sequence performed by the valve being changed according to the axial position, as follows.

The arrangement 56B has some similarities to the arrangement 56 (Fig. 4) in that each full turn of the arrangement 56B produces one complete cycle of the piston 18. However, the axial position of the arrangement 56B allows the cycle to use either a wide supply to the port 46 and a narrow supply to the port 48 (for a powerful down stroke and a relatively weak up stroke, such as for installing pile members), or a wide supply to the port 48 and a relatively narrow supply to the port 46 (for a strong up stroke and a relatively weak down stroke, such as for use in extraction of pile members). These alternatives are achieved with replacing the piston, as follows.

The upper outlet 88A is divided at a horizontal plane by a divider 90A, leaving a relatively wide mouth above the divider 90A, and a relatively narrow mouth below. In the axial position shown in Fig. 6, it is the relatively wide mouth above the divider 90A which comes into communication with the outlet port 89A on each revolution. However, if the arrangement 56B is moved up to bring the divider 90A to the top of the outlet 88A, it will then be the relatively narrow mouth below the divider 90A which comes into communication with the outlet port 89A.

In similar manner, the lower outlet 88B is horizontally divided by a divider 90B, with a relatively wide mouth below the divider 90B, and a relatively narrow mouth above. In the axial position shown in Fig. 6, it is the relatively narrow mouth above the divider 90B which comes into communication with the outlet port 89B, but if the arrangement 56B is moved up to bring the divider 90B to the top of the port 89B, the wide mouth below the divider 90B will then come into communication with the port 89B on each revolution.

By virtue of this arrangement, the sequence of the piston 18 can be "reversed", either to provide strong downward forces for installation, or strong upward forces for extraction.

The axial position of the arrangement 56B is set by a vertical drive arrangement 92 controlled through a valve 94 which allows the arrangement

56B to be driven upwardly, downwardly or locked in position.

Fig. 7 shows a further alternative valve arrangement 56C. In this arrangement, the axial position can be selected to choose between either a high frequency, low amplitude oscillation or a low frequency, high amplitude oscillation. During pile driving, low frequency may be preferred for its effectiveness, but gives rise to vibrations which travel further than higher frequencies. Higher frequencies are less problematic from this point of view, but generally less effective for driving. An advantage of the arrangement 56C is that high or low frequency can readily be chosen according to the operating conditions, simply by changing the axial position, as follows.

The arrangement of Fig. 7 has some similarities with Fig. 5, in that two upper outlets 104A are provided at diametrically opposite positions, to produce two down strokes for each rotation of the arrangement 56C. The upper outlets 104A are relatively narrow. Consequently, the sequence of the piston 18 is relatively high frequency, but low in amplitude.

One of the upper outlets 104A (the left hand outlet as shown in Fig. 8) is separated from a wider outlet 104C by a divider 106. The arrangement 56C can be raised from the position shown until the outlet 104C is at the appropriate height to come into communication with the port 107 on each revolution of the arrangement. That has the effect of halving the frequency of the sequence, but the relatively wide outlet 104C creates relatively high amplitude movement of the piston 18.

Fig. 8 shows a further alternative valve arrangement 56D in which the axial position is again relevant. Again, the arrangement 56D is broadly similar to the arrangement shown in Fig. 4, in that one cycle of the piston 18 is created by each full turn of the valve arrangement 56D. However, the upper outlet 96A is significantly different to the corresponding parts previously described, as can be seen from Fig. 7C. The circumferential width of the outlet 96A reduces with increasing height up the axis of the arrangement 56D. The outlet 96A is

broadly triangular. The axial length of the outlet 96A is greater than the axial length of the port 100 in the wall. Consequently, the total area through which the inner space 102 can communicate with the port 100 will depend on the vertical position of the triangular outlet 96A. As the arrangement 56D moves axially upwardly, the area increases, which reduces the restriction on hydraulic fluid and thus allows a greater volume of hydraulic fluid to pass within the time allowed by the turning of the arrangement 56D. In consequence, a higher axial position corresponds with a larger amplitude of piston movement, and this amplitude is continuously adjustable by setting the axial position of the arrangement 56D.

It can readily be understood that the various valve arrangements shown in Figs. 4 to 8 are interchangeable thus giving the apparatus a modular format and allowing apparatus to be readily adapted for different operating requirements.

Fig. 9 shows a modification relating to the piston 18C. The piston 18C has a hollow bore 107 through which the anvil 55A extends, having enlarged heads above and below the piston 18C. Return springs 57A, 57B bear on the anvil 55A from above and below. Consequently, and depending on the nature of the valve cartridge being used, the piston member 18C can be driven to impact on the upper head or on the lower head. Impact on both heads is not desirable. It is particularly preferred to use the valve arrangement illustrated in Fig. 6, which provides asymmetric fluid supply so that the unit will operate either for installation or extraction. In the condition shown, with the piston 12C free to slide relative to the anvil 55A, the operation is by impact, but an arrangement could be provided to lock the piston 18C to the anvil 55A to produce operation by vibration.

Fig. 10 shows an arrangement in which two piling machines of the general type described above are used together. In this example, a lower machine 110A is similar to the machine shown in Fig. 3, to provide vibration by means of a valve arrangement 112A generally as shown in Fig. 4. A second

machine 110B is mounted above the machine 110A and is an impact arrangement of the type shown in Fig. 4. However, no plate 30 is provided. Instead, the upper cap is removed from the lower machine 110A so that the piston of the upper machine 110B can strike down against the piston of the lower machine 110A. In addition, the shaft 60 is extended up through both valve arrangements 112A, 112B so that both can be driven by a single motor 114 in order to co-ordinate the two arrangements.

It will be apparent that many variations and modifications can be made to the apparatus as described above without departing from the scope of the present invention. In particular, many features can be used interchangeably in combinations other than those described, which is a particular benefit of the invention. The block member could be assembled from more than one part. Many other piston operation sequences could be devised by appropriate modification of valve arrangements, so that operation of a machine can be modified at will by the simple expedient of appropriate modification to the valve assembly, thus retaining the machine flexible in its application.

Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

CLAIMS

1. Actuator apparatus for driving piles and like members, comprising piston means operable to create driving forces from a supply of pressurised fluid, and valve means operable to supply pressurised fluid to the piston means according to a predetermined sequence, to cause the apparatus to execute a first operation, the valve means and the piston means being housed within a common block member, and the valve means or the piston means or both being removable from the block member for replacement by an alternative means operable within the block member to cause the apparatus to execute an alternative operation.

2. Apparatus according to claim 1, wherein the valve means is removable for replacement with an alternative valve means operable to supply fluid according to an alternative sequence.

3. Apparatus according to claim 1 or 2, wherein the valve means comprise a spindle movable within a housing, there being hydraulic ports in the housing walls, and the spindle carrying partitions which serve to change the connections between the hydraulic ports in accordance with the spindle position.

4. Apparatus according to claim 3, wherein the spindle is rotatable to provide port connections in accordance with the predetermined sequence.

5. Apparatus according to claim 3 or 4, wherein the spindle is axially movable to change the predetermined sequence.

6. Apparatus according to claim 5, wherein the spindle has a first axial position at which a wider fluid path is provided to one face of the piston means than to the other, and is movable to a second axial position at which a narrower fluid path is provided to the said one face than to the other.

7. Apparatus according to claim 5 or 6, wherein the valve means has a port

having a width which is not constant in the axial direction of the spindle, whereby the effective width of the fluid path to the piston means can be set by setting the axial position of the spindle.

8. Apparatus according to any of claims 3 to 7, wherein the spindle provides drive alternatively to opposite faces of a piston of the piston means, whereby to create reciprocation.

9. Apparatus according to any of claims 3 to 8, wherein the spindle is formed to complete a plurality of cycles of the piston means for each full turn of the spindle.

10. Apparatus according to claim 9, wherein the spindle has a first axial position in which a first number of cycles are completed for each full turn of the spindle and a second axial position in which a different number of cycles is completed for each full term.

11. Apparatus according to claim 10, wherein the fluid path to the piston means is relatively narrow in the first axial position, and relatively wide in the second axial position.

12. Apparatus according to any preceding claim, wherein the valve means comprise at least one member which is movable to alternative positions to cause the predetermined sequence to change in accordance with its position.

13. Apparatus according to any preceding claim, further comprising intermediate means to which driving forces are provided by the piston means, and which convey driving forces to clamping members by which a workpiece may be clamped.

14. Apparatus according to claim 13, wherein the clamping members extend at an angle to the intermediate means to allow side or end clamping of a

workpiece.

15. Apparatus according to claim 13 or 14, wherein the intermediate means is elongate.

16. Apparatus according to claim 15, wherein the intermediate means extends to one side of the common block member.

17. Apparatus according to claim 14, 15 or 16, wherein the clamping members extend substantially perpendicular to the intermediate means.

18. Apparatus according to any of claims 13 to 17, wherein the intermediate means extend through a passage within the piston means, and have enlarged heads against which the piston means may act in either of two opposite directions.

19. Apparatus according to any preceding claim, wherein the common block member is arranged for attachment to the block member of a like apparatus, to allow the piston means of one apparatus to apply impact forces to the piston means of the other apparatus, the other apparatus being operable to provide vibratory forces.

20. Apparatus according to any preceding claim, wherein the apparatus is adapted for resilient attachment to a mounting arrangement by means of which the apparatus may be supported by a conventional support arrangement.

21. Apparatus according to claim 20, wherein the support arrangement is provided by a conventional excavator or like machine.

22. Apparatus according to claim 21, wherein the support machine is operable to apply crowd forces to the apparatus.

23. Apparatus according to claim 21 or 22, wherein the support machine is

able to supply pressurised fluid to the apparatus.

24. Actuator apparatus substantially as described above, with reference to the accompanying drawings.

25. Any novel subject matter or combination including novel subject matter disclosed herein, whether or not within the scope of or relating to the same invention as any of the preceding claims.

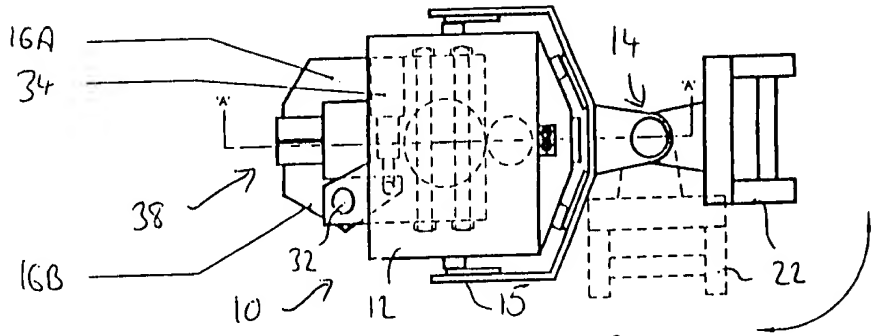

FIG. 2

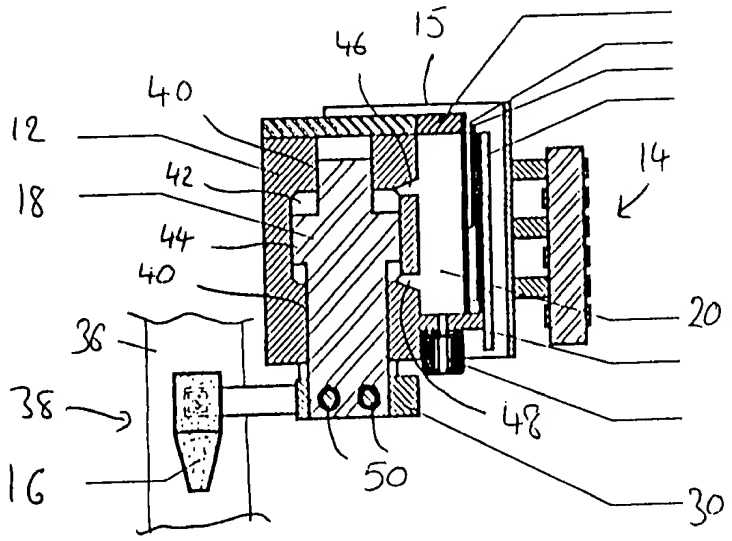

FIG. 3

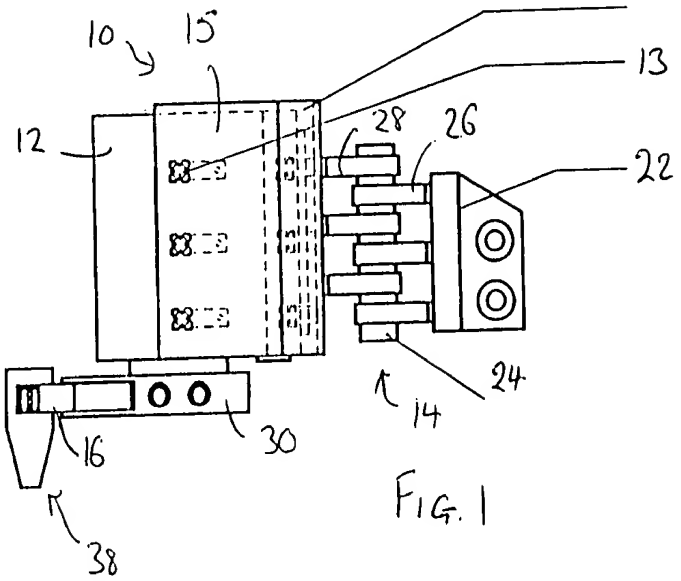

FIG. 1

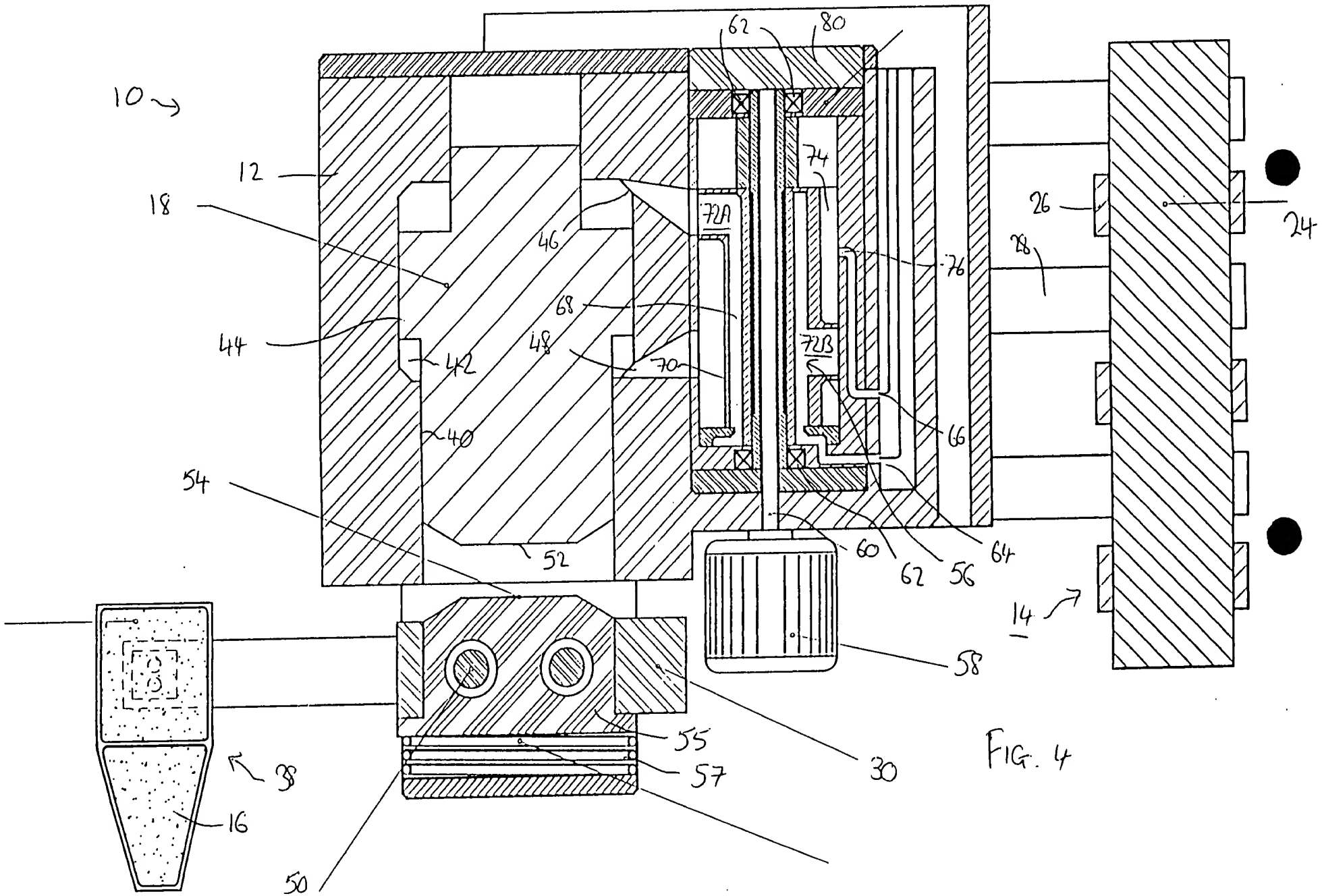
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FIG. 4

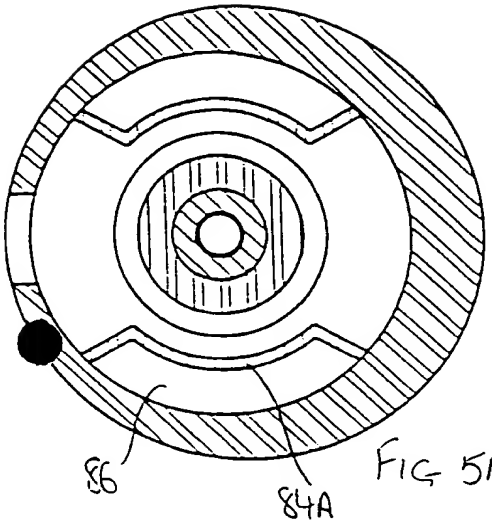

FIG 5A

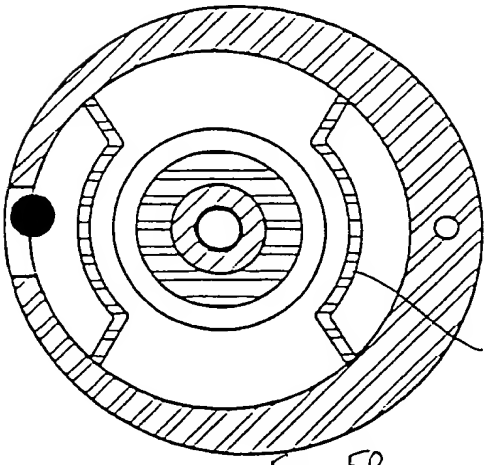

FIG. 5B

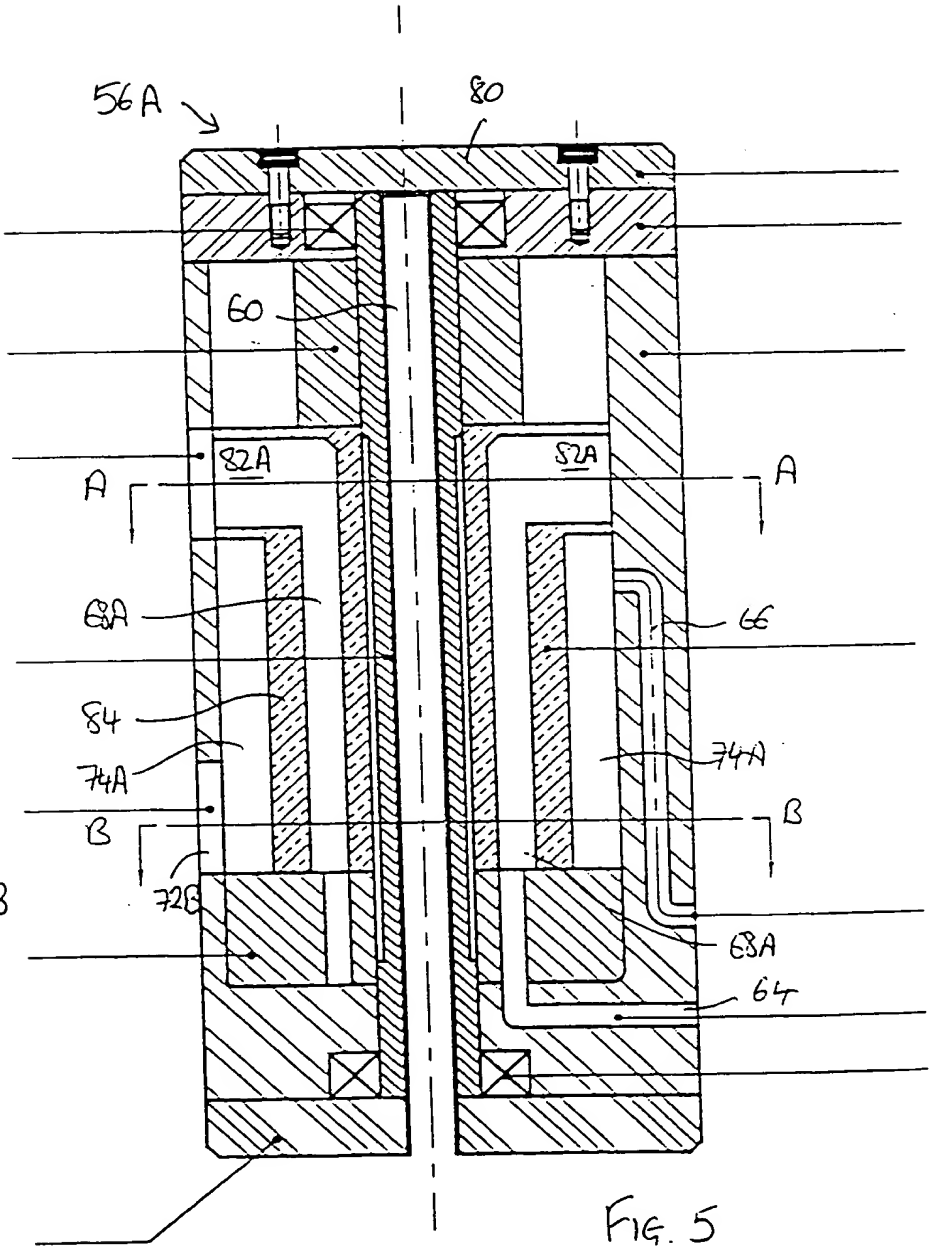

FIG. 5

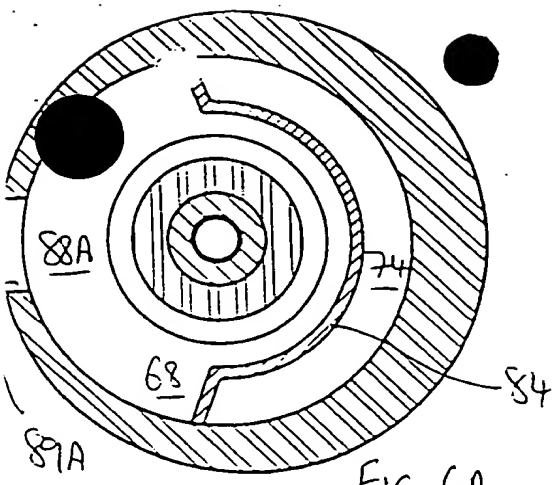

FIG 6A

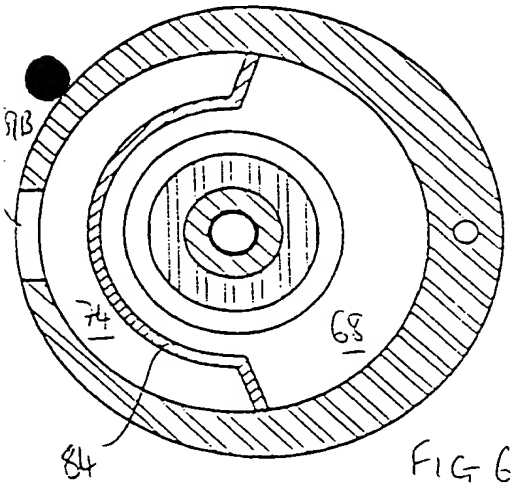

FIG 6B

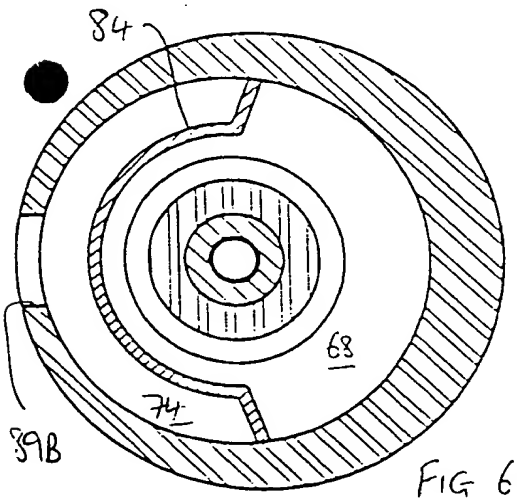

FIG 6C

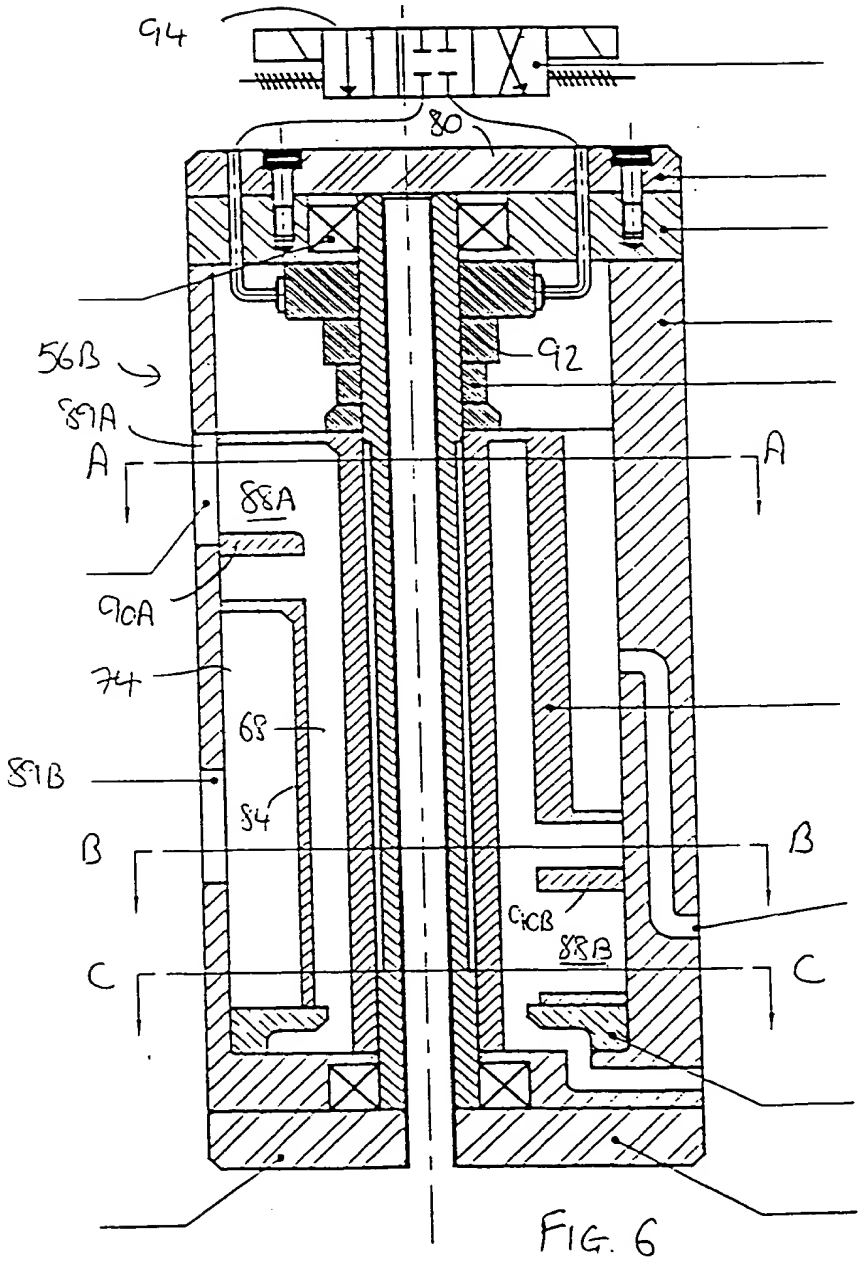

FIG. 6

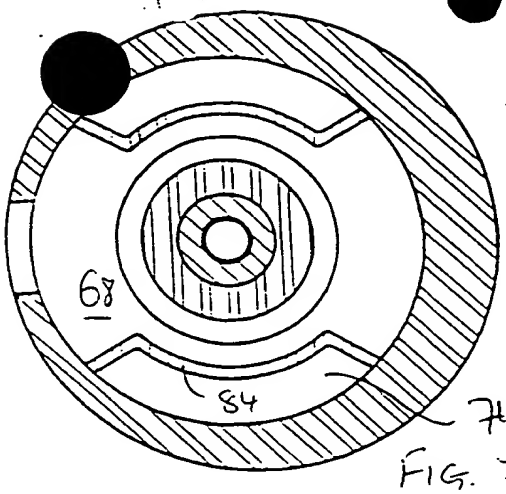

FIG. 7A

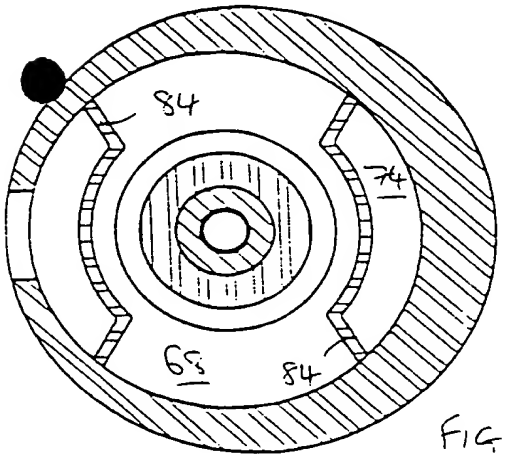

FIG 7B

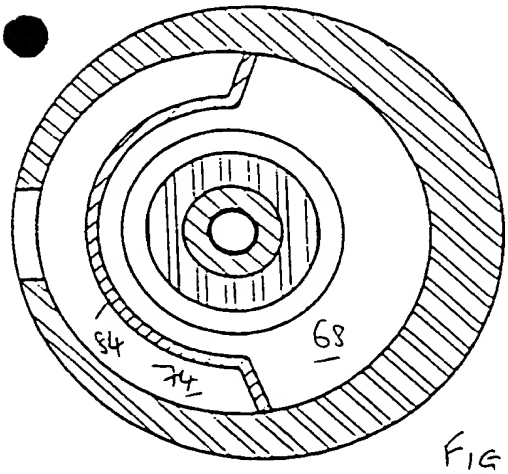

FIG 7C

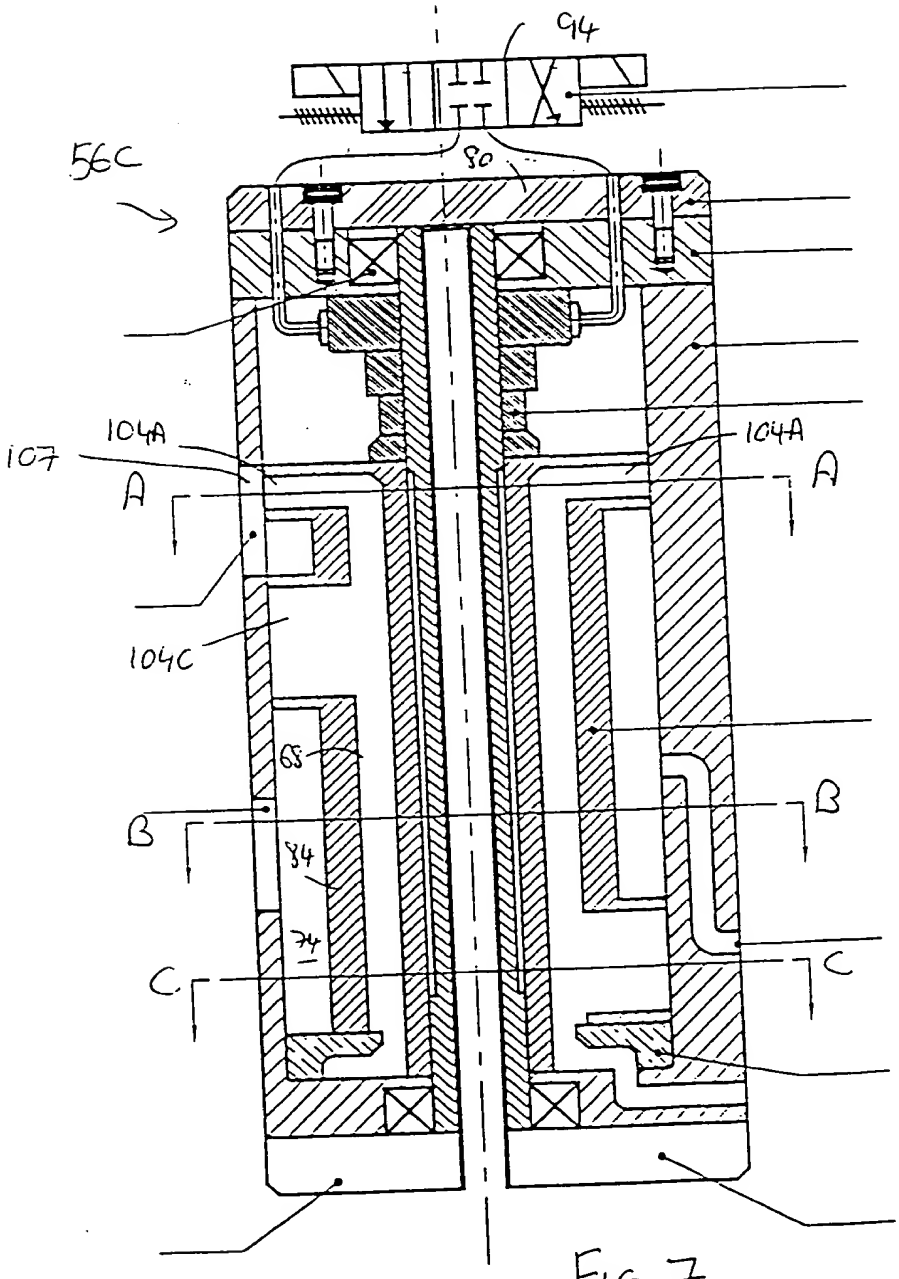

FIG. 7

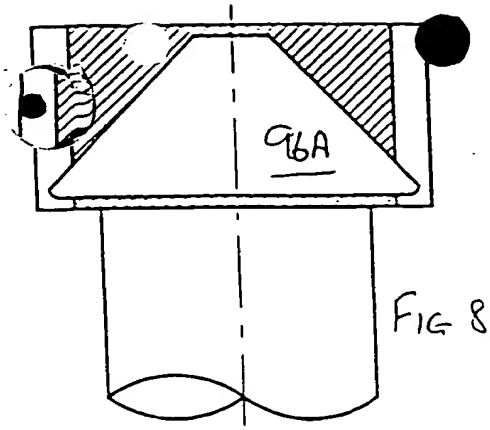

FIG 8C

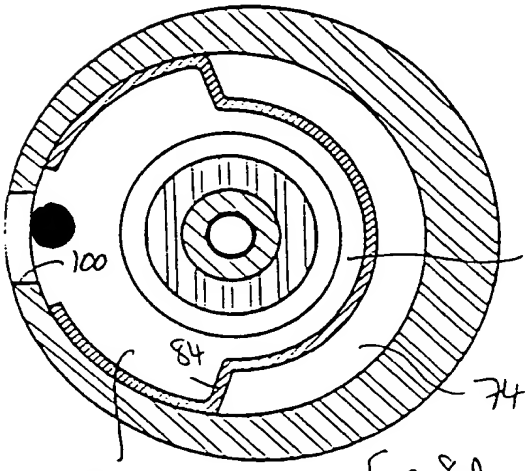

FIG 8A

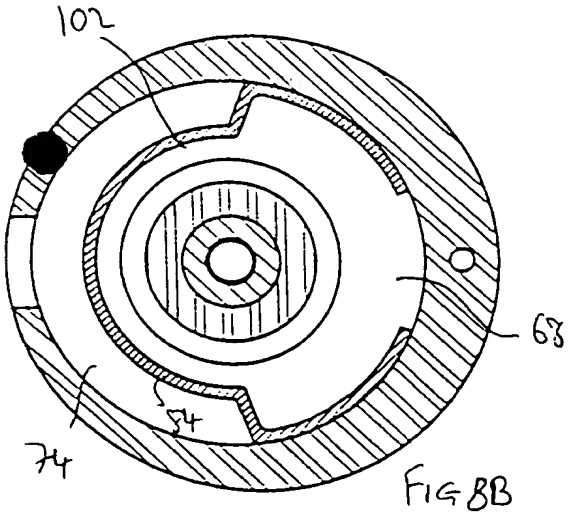

FIG 8B

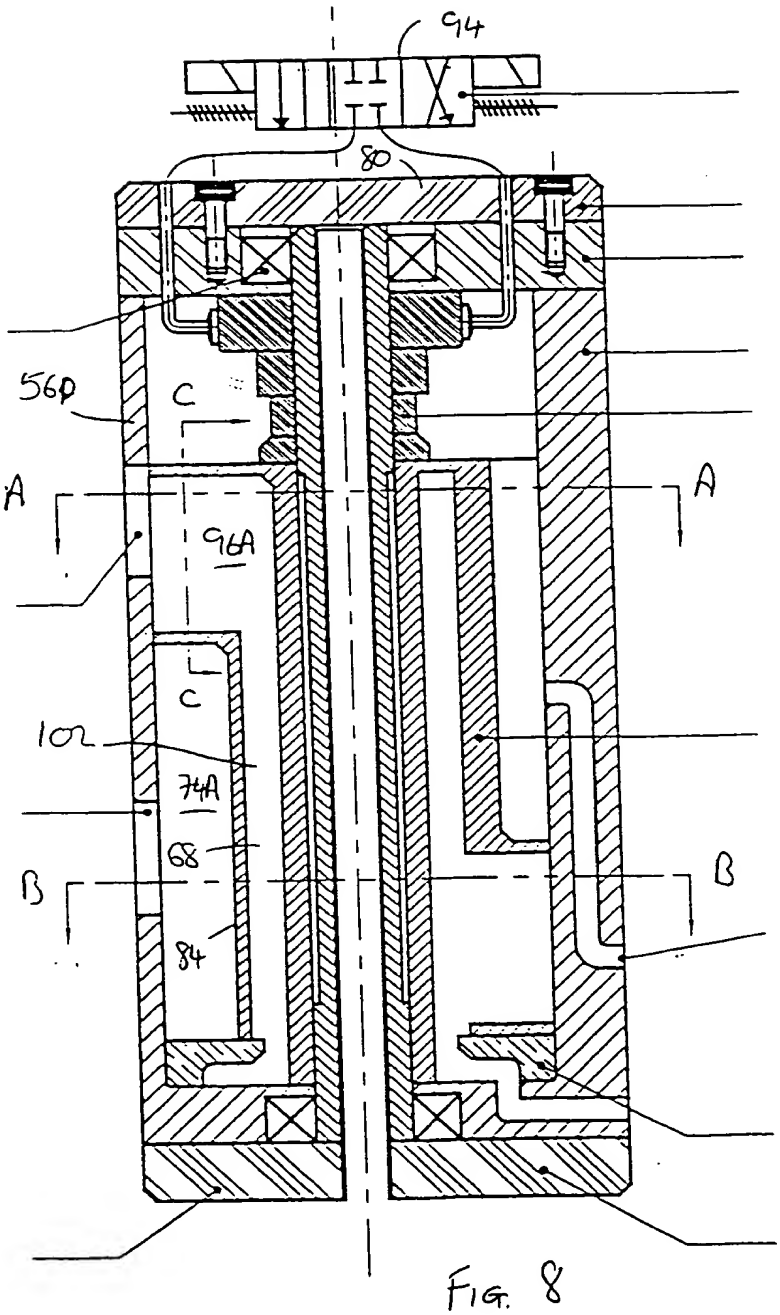

FIG. 8

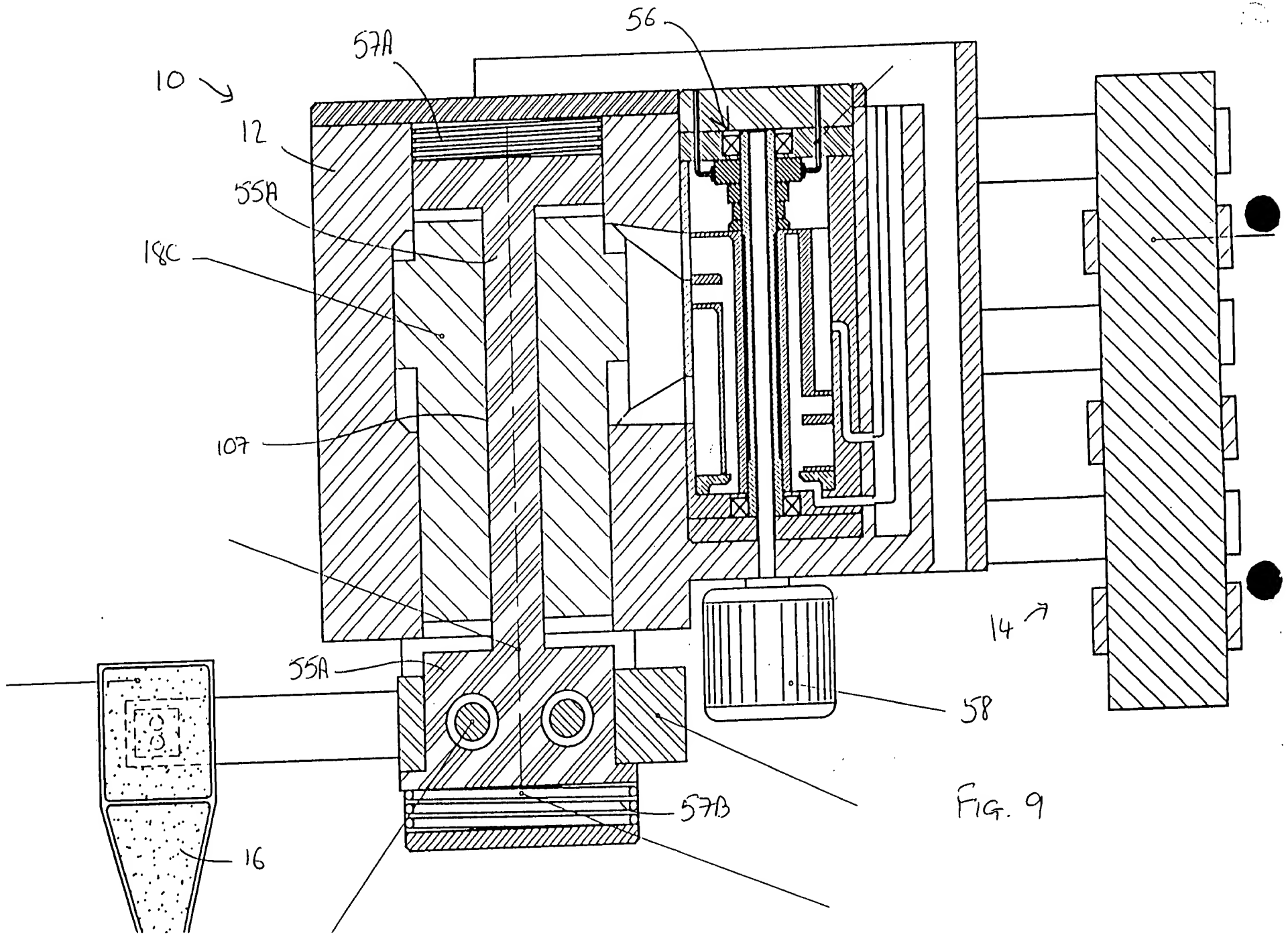

FIG. 9

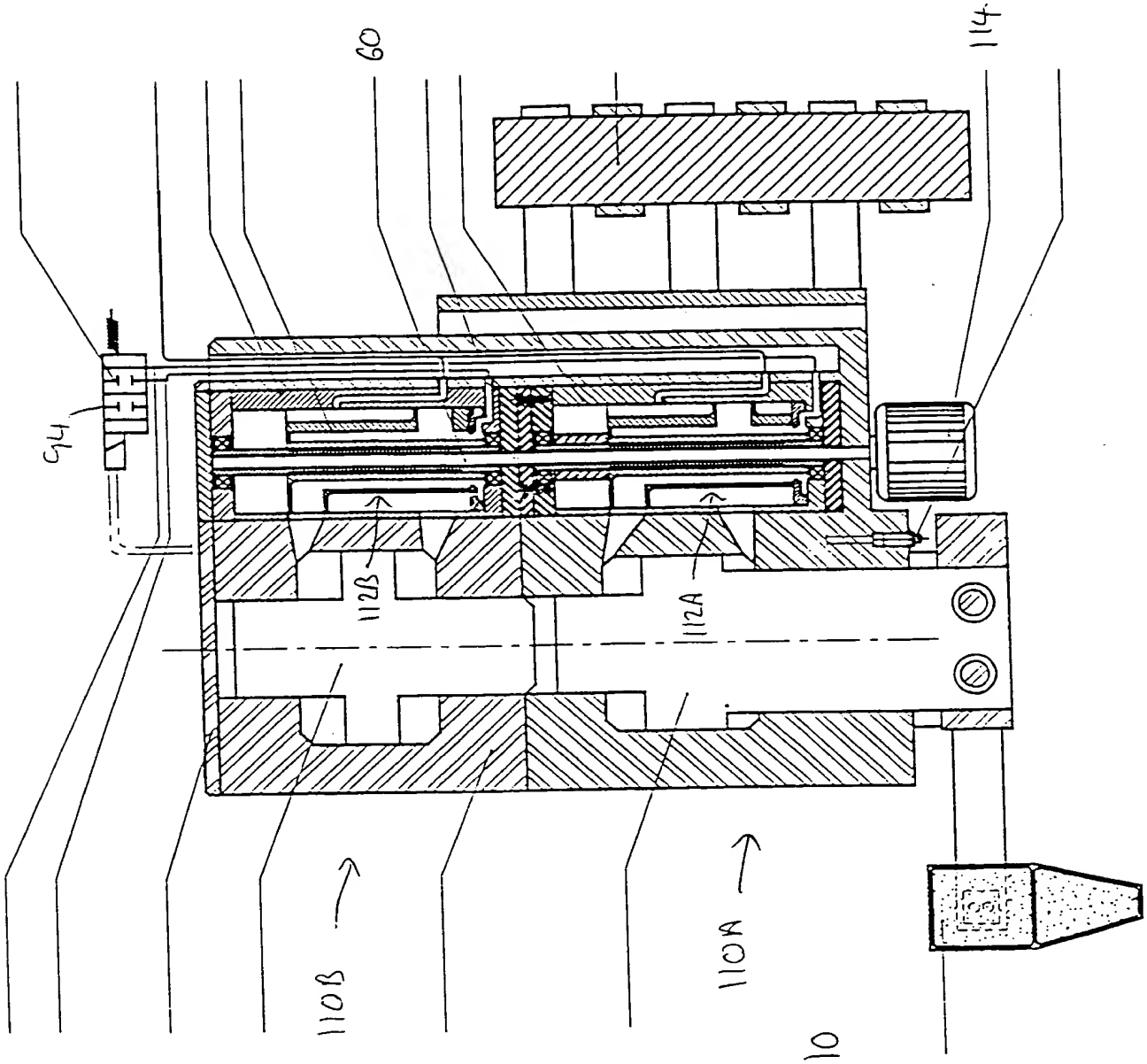

FIG. 10

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